

CLAIMS

1. A reciprocating engine comprising:
 - a first piston ring adjacent to a top surface of a piston defining a combustion chamber;
 - a second piston ring which defines an annular gas chamber in cooperation with said first piston ring and which is adjacent to said first piston ring such that a pressure-receiving area of a side surface of said piston in said annular gas chamber becomes greater on a thrust side than on a counter-thrust side; and
 - a plurality of gas passages which are disposed in an inner surface of a cylinder in such a manner as to be juxtaposed in a circumferential direction of the inner surface of said cylinder and which allow said annular gas chamber to communicate with said combustion chamber on the thrust side.
2. The reciprocating engine according to claim 1, wherein said plurality of gas passages respectively have recessed portions which are disposed in the inner surface of said cylinder at positions for allowing said annular gas chamber to communicate with said combustion chamber when said piston is at a top dead center or during a starting period of the fall from the top dead center.
3. The reciprocating engine according to claim 2, wherein said plurality of recessed portions are adapted to allow only said annular gas chamber to respectively communicate with said combustion chamber.
4. The reciprocating engine according to claim 2 or 3, wherein said plurality of gas passages are disposed in the inner surface of said cylinder at positions for allowing said annular gas chamber to communicate with said combustion chamber during the starting period of the fall of said piston from the top dead center.

5. The reciprocating engine according to any one of claims 2 to 4, wherein at least one of said recessed portions is disposed in the inner surface of said cylinder at a position for allowing said annular gas chamber to communicate with said combustion chamber when said piston is positioned at the top dead center.

6. The reciprocating engine according to any one of claims 2 to 5, wherein said at least one of said recessed portions is disposed in such a manner as to be located further away from a cylinder head than other ones of said recessed portions concerning a reciprocating direction.

7. The reciprocating engine according to any one of claims 2 to 6, wherein said at least one of said recessed portions which is located most away from a counter-thrust-side portion of said piston is disposed further away from said cylinder head than said other ones of said recessed portions concerning the reciprocating direction.

8. The reciprocating engine according to any one of claims 2 to 7, wherein a center portion of an opening plane of a space defined by said at least one of said recessed portions is disposed in such a manner as to oppose a center portion of said piston concerning a direction which is perpendicular to the reciprocating direction and an axial direction of a piston pin for coupling said piston and a connecting rod.

9. The reciprocating engine according to claim 6 or 7, wherein a portion located on a cylinder head side in a contiguous portion, which is contiguous to the cylinder inner surface of said recessed portion disposed further away from said cylinder head, is disposed closer to the cylinder head side than portions of contiguous portions contiguous to the cylinder inner surface in said other ones of said recessed portions and opposing in the reciprocating direction the portions thereof located on the cylinder head side.

10. The reciprocating engine according to any one of claims 2 to 9, wherein one portions of the opening planes of the spaces respectively defined by said plurality of recessed portions are respectively positioned on a line extending in a circumferential direction.

11. The reciprocating engine according to any one of claims 2 to 10, wherein there are provided a pair of recessed portions opposing each other concerning the axial direction of said piston pin for coupling said piston and said connecting rod, and a distance from said cylinder head to one of said recessed portions in the reciprocating direction and a distance from said cylinder head to the other one of said recessed portions in the reciprocating direction are mutually equal.

12. The reciprocating engine according to any one of claims 2 to 11, wherein said plurality of recessed portions respectively have partially concave spherical surfaces.

13. The reciprocating engine according to any one of claims 2 to 12, wherein an intersection angle between a line extending in the reciprocating direction and a tangential line to said contiguous portion contiguous to the cylinder inner surface in said at least one of said recessed portions is an obtuse angle.

14. The reciprocating engine according to any one of claims 2 to 13, wherein tangential lines to both portions opposing each other in the reciprocating direction in said contiguous portion contiguous to the cylinder inner surface in said at least one of said recessed portions intersect each other at a position located further away from said piston than said both portions.

15. The reciprocating engine according to any one of claims 2 to 12, wherein a line extending in the reciprocating direction and a tangential line to said contiguous portion contiguous to the cylinder inner surface in said at least one of said recessed portions are perpendicular to each other.

16. The reciprocating engine according to any one of claims 2 to 15, wherein said at least one of said recessed portions has a depth different from that of said recessed portion adjacent to that recessed portion in the circumferential direction.

17. The reciprocating engine according to any one of claims 2 to 16, wherein said at least one of said recessed portions is deeper than said other ones of said recessed portions located on the counter-thrust side relative to said recessed portion concerning the direction which is perpendicular to the reciprocating direction and the axial direction of said piston pin for coupling said piston and said connecting rod.

18. The reciprocating engine according to any one of claims 2 to 17, wherein said at least one of said recessed portions has a depth equal to that of said recessed portion adjacent to that recessed portion in the circumferential direction.

19. The reciprocating engine according to any one of claims 2 to 18, wherein there are provided a pair of recessed portions opposing each other concerning the axial direction of said piston pin for coupling said piston and said connecting rod, and an intersection angle between a line extending in the axial direction and a line connecting the center portion of said piston and the center portion of the opening plane of the space defined by said one of said recessed portions and an intersection angle between the line extending in the axial direction and a line connecting the center portion of said piston and the center portion of the opening plane of the space defined by said other one of said recessed portions are mutually equal.

20. The reciprocating engine according to claim 19, wherein said pair of recessed portions have mutually similar shapes.

21. The reciprocating engine according to any one of claims 2 to 20, wherein an interval between said both portions opposing each other in the reciprocating direction in each of said contiguous portions of said plurality of recessed portions contiguous to the

inner surface of said cylinder is greater than a thickness of said first piston ring.

22. The reciprocating engine according to any one of claims 2 to 21, wherein an interval between said both portions opposing each other in the reciprocating direction in each of said contiguous portions of said plurality of recessed portions contiguous to the inner surface of said cylinder is shorter than a distance in the reciprocating direction from a thrust-side portion of a defining surface of said first piston ring defining said annular gas chamber to a thrust-side portion of a defining surface of said second piston ring defining said annular gas chamber.

23. The reciprocating engine according to any one of claims 2 to 22, wherein the opening plane of the space defined by said at least one of said recessed portions has a diameter different from the opening plane of said space defined by said other one of said recessed portions.

24. The reciprocating engine according to any one of claims 2 to 23, wherein the opening plane of the space defined by said at least one of said recessed portions has a diameter longer than the opening plane of said space defined by said recessed portion located closer to the counter-thrust side relative to said recessed portion concerning the reciprocating direction and the axial direction of said piston pin for coupling said piston and said connecting rod.

25. The reciprocating engine according to any one of claims 2 to 24, wherein there are provided a pair of recessed portions opposing each other concerning the axial direction of said piston pin for coupling said piston and said connecting rod, and the diameter of the opening plane of the space defined by each of said pair of recessed portions and the diameter of the opening plane of the space defined by another recessed portion adjacent to said pair of recessed portions in the circumferential direction are mutually different.

26. The reciprocating engine according to any one of claims 2 to 25, wherein the opening plane of the space defined by said at least one of said recessed portions has a diameter equal to that of the opening plane of said space defined by another one of said recessed portions.

27. The reciprocating engine according to any one of claims 1 to 26, wherein the defining surface said first piston ring defining said annular gas chamber is disposed so as to be parallel to a plane perpendicular to the reciprocating direction.

28. The reciprocating engine according to any one of claims 2 to 27, wherein the diameter of the opening plane of the space defined by said at least one of said recessed portions is greater than a depth of that recessed portion.

29. The reciprocating engine according to any one of claims 1 to 28, wherein said piston ring is disposed in such a manner as to be inclined with respect to the reciprocating direction.

30. The reciprocating engine according to any one of claims 1 to 29, further comprising an oil ring disposed on said piston in face-to-face relation to said first piston ring with said second piston ring located therebetween, and a thrust-side portion of said oil ring is located further away from said first piston ring than a portion of said oil ring opposing said piston pin for coupling said piston and said connecting rod concerning the reciprocating direction.

31. The reciprocating engine according to claim 30, wherein said thrust-side portion of said oil ring is located further away from said first piston ring than a counter-thrust-side portion of said oil ring.

32. The reciprocating engine according to claim 29, further comprising an oil ring disposed on said piston in face-to-face relation to said first piston ring with said second piston ring located therebetween, and said oil ring is disposed in such a manner as to be

inclined with respect to the reciprocating direction.

33. The reciprocating engine according to claim 32, wherein said oil ring and said second piston ring are disposed in such a manner as to be inclined with respect to the reciprocating direction with mutually equal angles.

34. The reciprocating engine according to any one of claims 1 to 33, wherein said piston pin for coupling said piston and said connecting rod are off-centered toward the counter-thrust side.

35. A reciprocating engine comprising:

- a first piston ring adjacent to a top surface of a piston defining a combustion chamber;

- a second piston ring which defines an annular gas chamber in cooperation with said first piston ring and which is adjacent to said first piston ring such that a pressure-receiving area of a side surface of said piston in said annular gas chamber becomes greater on another swinging side surface portion opposing one swinging side surface portion of said piston than on said one swinging side surface portion;

- an oil ring which is located further away from said first piston ring on the other swinging side surface portion side than on a substantially intermediate portion side between the one swinging side surface portion and the other swinging side surface portion; and

- a gas passage formed in at least one of said piston and an inner surface of a cylinder and adapted to allow said annular gas chamber to communicate with said combustion chamber.

36. The reciprocating engine according to claim 35, wherein said second piston ring is disposed in such a manner as to be inclined with respect to a reciprocating direction of said piston.

37. The reciprocating engine according to claim 35 or 36, wherein said oil ring is disposed in such a manner as to be inclined with respect to a reciprocating direction of said piston.

38. The reciprocating engine according to any one of claims 35 to 37, wherein said one swinging side surface portion is located on a counter-thrust side, and said other swinging side surface portion is located on a thrust side.

39. The reciprocating engine according to any one of claims 35 to 38, wherein said gas passage is constituted by a recessed portion which is disposed in the inner surface of said cylinder at a position for allowing said annular gas chamber to communicate with said combustion chamber when said piston is positioned at a top dead center.